MINING METHODS AND COSTS, CONTINENTAL URANIUM, INC., CONTINENTAL NO. 1 MINE SAN JUAN COUNTY, UTAH

BY W. L. DARE

* * * * * * * * * * Information Circular 7801

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W. L. Dare[1/]

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SUMMARY AND INTRODUCTION

This paper is one of a series being prepared by the Bureau of Mines on the methods and costs of mining uranium on the Colorado Plateau.

The Continental No. 1 mine is at the south end of the Big Indian mining district, San Juan County, Utah. The mine is on a school section owned by the State of Utah and leased by Continental Uranium, Inc. A 70,000-ton uranium-vanadium ore deposit was discovered as a result of an exploratory drilling program completed in 1954.

Although the Continental No. 1 mine is one of the smaller mines of the Big Indian district, it is larger than the majority of the uranium mines on the plateau. The ore body is elongated along the east-west strike of the Moss Back member of the Triassic Chinle formation. It is roughly tabular in shape but irregular in outline and dips about 8° to 10° to the south. The ore occurs at the base of the Moss Back, within 2 feet of the Permian Cutler formation. The ore mined to date has an average thickness of about 7 feet. It is developed by a 350-foot slope and a haulageway driven within the ore stratum and mined by open stoping with random pillar support. The height of the ore, its gentle dip, and the strength of the overlying rock have permitted use of trackless loading and haulage equipment.

The sections of this report that pertain to location, physical features, history, and geology are brief because much of the same information was given in detail in earlier information circulars on other operations in the district.

ACKNOWLEDGMENTS

The cooperation and assistance given by the management and staff of Continental Uranium, Inc., in preparing this paper, are gratefully acknowledged. C. H. Reynolds, general superintendent, was particularly helpful. Clarence Cox, mine foreman, Glen Smith and Tom Edwards, shifters, and Vin Gray all cooperated in providing data on the mining operation.

LOCATION AND PHYSICAL FEATURES

The Continental No. 1 mine is in sec. 36, T. 30 S., R. 25 E., Salt Lake meridian, San Juan County, Utah. (See fig. 1.) The mine is about 32 miles southeast of Moab, Utah, at the south end of the Big Indian mining district. The mine is reached from Moab by traveling south on U. S. Highway 160 for 22.1 miles, east on the newly paved Utah State Highway 46 for 6.6 miles, southeast on the Big Indian Wash-Lisbon Valley road for 14.9 miles, and finally west 1.1 miles to the mine. The mine plant is on a small flat between lower Lisbon Valley and Three Step Hill; its altitude is 6,600 feet. (See fig. 2.)

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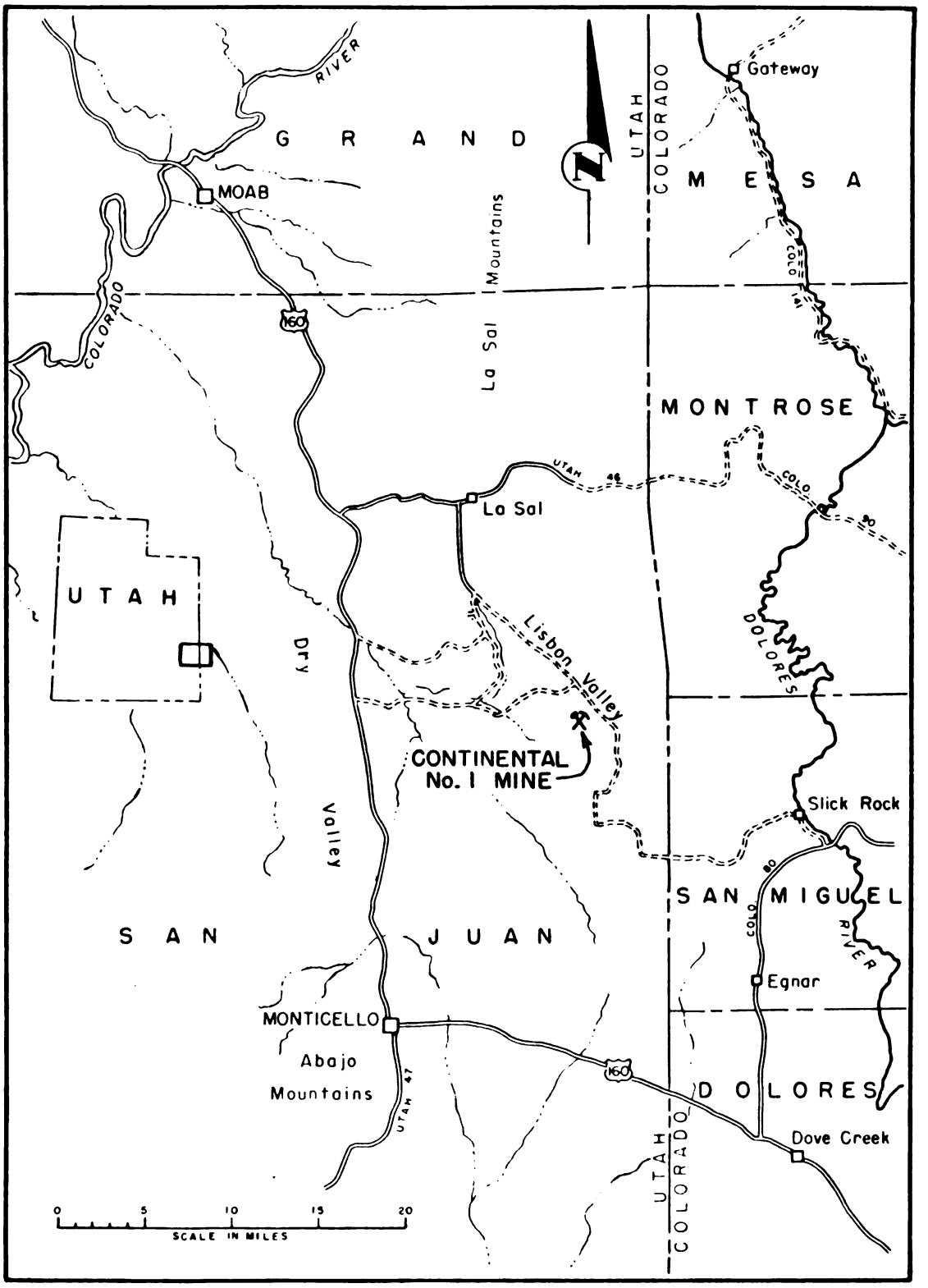

Figure 1. - Location map, Continental No. 1 mine, San Juan County, Utah.

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Figure 2. - Surface plant Continental No. 1 mine.

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Topography in the area is typical of the semidesert Colorado Plateau. Flat-lying valleys are surrounded by rugged canyon lands and isolated mesas. Sparse vegetation and heavy rains have resulted in a complex erosion pattern leaving irregularly shaped mesas walled by cliff-forming sandstones. Within 1 mile of the Continental No. 1 mine altitudes range from 6,400 to 7,200 feet. The laccolithic La Sal Mountains begin about 17 miles north of the mine, with Mount Peale rising to 12,721 feet above sea level.

The climate is dry. The area is subject to short severe storms during any season. The winters are moderately severe, with snowfalls that average about 6 inches but can accumulate to greater depths. The summers are hot, with temperatures rising to above 100° F. Summer rains occur mostly as heavy downpours, sometimes causing local flash floods. Water for camp use is hauled from a well 5 miles away.

Vegetation in the valleys consists principally of sage; pinon pine and juniper grow mainly on the slopes and higher areas. No timber that can be used for mining purposes grows in the district.

HISTORY AND PRODUCTION

Mining began in about 1904 in the old Dry Valley mining district, which is about 4 miles southwest of the Continental No. 1 mine. This district was first developed when carnotite ores, found in the Salt Wash member of the Jurassic Morrison formation, were mined for their radium content. The same-type ores were mined intermittently for vanadium between World War I and World War II and for their uranium content since 1946.

Copper ores also were mined intermittently from a few small deposits that occur in the undifferentiated Cretaceous Burro Canyon sandstone and the Dakota formation that are exposed along the downthrow side of the Lisbon Valley fault. The first recorded ore production from the district came from the Big Indian mine in 1908. This mine is about 11 miles northwest of the Continental No. 1 mine. A similar deposit was found in the Black Bird mine, which is 1 mile north of the Continental No. 1. Copper ore was last produced from the Big Indian mine by Ohio Copper Co. during World War II.

The earliest known production of uranium-vanadium ores from the Triassic Chinle formation in the area came from the Divide and Serviceberry mines in 1917. Oxidized uranium-vanadium-bearing rock was found in the Chinle about 1/2 and 1-1/2 miles west of the Continental No. 1 mine. Both mines were small producers. Between 1948 and 1955 sporadic production came from a number of small mines in the Permian Cutler formation, which is exposed along the escarpment that borders the west side of Big Indian Wash.

The first major discovery in the Big Indian district was in July 1952, when Charles A. Steen made his discovery in the Chinle formation. Following this, exploratory drilling by many firms and individuals has resulted in the discovery of additional large deposits along the southwest flank of the Lisbon Valley anticline.

Sec. 36, T. 30 S., R. 25 E. is a school section owned by the State of Utah. On April 27, 1953, Gerald Gidwitz, doing business as Western Mines Development Co., acquired a mineral lease on this section which was approved on May 11, 1953, by the Utah State Land Board. On May 7, 1954, the State Land Board approved the assignment of 77.972 percent of the lease to Willard and Joseph Gidwitz, brothers of Gerald, and others. This organization was known as the Gidwitz Group. Members of the

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Gidwitz Group assigned their interests to the newly organized Continental Uranium, Inc., on August 31, 1954, in exchange for a controlling block of the new company's common stock.

The ore body was discovered as a result of a diamond-drilling program that was begun in 1953 and completed early in 1954. The Junction Bit & Tool Co. of Grand Junction, Colo., was then given a contract to drive the incline and mine the ore under a cost-incurred plus fixed-fee basis. The contractor started the incline in March 1954 and shipped the first ore May 16, 1954. This contract was terminated; and since October 10, 1955, the mine has been operated by company personnel.

Before August 1956 the Utah State Mineral Lease required payment of a standard 12-1/2-percent royalty on all proceeds from ore sales, less assay charges and transportation costs to the point of sale, and a rental of $0.50 per acre per year to be credited to royalties due. The main requirement was diligent and continuous operation. On April 1, 1956, Continental Uranium, Inc., elected to pay the royalty on the basis of a sliding-scale schedule that had been adopted by the State on March 23, 1956. The lessee now pays a basic royalty of 3.9 percent on ores having a gross value of $3.99 a ton or less. This rate is applied to the net value of the ore, which is the gross value of its U_3O_8 and V_2O_5 content less any initial bonus, mine-development allowance, transportation allowance, or lime penalty. For each increase of $1.00 in the gross value of the ore above $4.00 per ton, the royalty is increased by an additional 0.3 percent, reaching a maximum of 17.4 percent on ore having a gross value of $48.00 or more per dry ton. In addition to the above, an 8.0-percent royalty is paid on any bonus received.

LABOR AND LIVING CONDITIONS

The Continental No. 1 mine camp is about 1,300 feet north of the mine plant. The men live in either of two small, company-owned bunkhouses or in privately owned trailer houses. The company operates a cook house and charges $2.40 per day for room and board. A warehouse and an office building are at the camp. All buildings are prefabricated wooden structures. Electric power for camp use is furnished by a generator unit. Camp water is hauled 5 miles from a spring in Lisbon Canyon.

Labor supply is good in the district, and labor turnover at the Continental No. 1 mine has been relatively low.

GENERAL GEOLOGY AND DESCRIPTION OF DEPOSIT[2 3 4/]

The Continental No. 1 mine is on the southwest flank of Lisbon Valley anticline, about 100 feet west of the Lisbon Valley fault. In general, the fault lies along the axis of the anticline; they both strike northwest. The ore deposit occurs at the south nose of the anticline, where the formations strike almost due west. The dip of the beds is 8° to 10° to the south.

2/ Dix, G. P., Jr., The Uranium Deposits of Big Indian Wash, San Juan County, Utah: AEC, RME-4022, 1953, 15 pp.

3/ Steen, C. A., Dix, G. P., Jr., Hazen, S. W., Jr., and McLellan, R. R., Uranium-Mining Operations of the Utex Exploration Co. in the Big Indian District, San Juan County, Utah: Bureau of Mines Inf. Circ. 7669, 1953, 13 pp.

4/ Lekas, M. A., and Dahl, H. M., The Geology and Uranium Deposits of the Lisbon Valley Anticline, San Juan County, Utah: Intermountain Assoc. Petrol. Geologists, 7th Annual Field Conference, 1956, pp. 155-168.

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The formations exposed in the immediate area range from the undifferentiated Cretaceous Burro Canyon-Dakota formations to the undifferentiated Permian Rico-Cutler formations. The Triassic Chinle formation contains the more important ore deposits in the Big Indian mining district. It is about 400 feet thick and composed principally of red and green mudstone and siltstone, with interbedded sandstone and conglomerate. The Permian Cutler formation lies under the Chinle. It is about 880 feet thick and consists mainly of red, purple, and brown mudstone and red, purple, and white sandstone and conglomerate. Small uranium ore bodies, occurring in arkosic sandstone lenses in the Cutler formation, have been mined to the north in Big Indian Wash. The Triassic Wingate sandstone overlies the Chinle formation. It is an orange-red, massive, cliff-forming sandstone and composes part of Three Step Hill directly west of the mine. Only about 50 to 200 feet of the Wingate is exposed in the area. A few miles west and southwest a number of small uranium-vanadium deposits were mined along the rim exposure of the Salt Wash member of the Jurassic Morrison formation.

The Continental No. 1 ore bodies occur at the base of the Chinle formation in the ill-defined basal member called the Moss Back sandstone. The Moss Back is a gray and greenish-gray sandstone with lenses of green mudstone, siltstone, and conglomeratic sandstone. The ore occurs in the bottom 20 feet of the Moss Back within 2 feet or less of the Cutler contact. The thicker ore occurs in the thicker sandstone. The deposit consists of 2 separate ore bodies that strike about N. 87° W. The east ore body is the larger, thicker, and higher grade of the two. The ore dips 8° to 10° southward. The average thickness of the ore mined to date has been about 7 feet; its maximum thickness, about 9 feet.

In places low-grade uranium mineralization extends as much as 2 feet into a buff, friable sandstone which lies at the top of the Cutler. A high-grade seam of black uranium ore often occurs a short distance above the contact with lower grade ore above it. The ore minerals are uraninite and montroseite. The ratio of vanadium to uranium is about 2:1.

The sandstone that overlies most of the ore, if reinforced by roof bolts, stands well across open spans approaching 30 feet. Where mudstone lies above the ore, it sloughs unless adequately held by roof bolts.

METHOD OF EXPLORATION

The totally hidden ore body was discovered by exploratory surface drilling that began in 1953 and was completed early in 1954. To define the deposit 170 holes were drilled on about 50-foot centers. Seventy holes penetrated ore-grade mineralization. Plug bits were used to drill to near the ore horizon, which was then cored with NX-size diamond bits. About 10 feet of the Cutler formation was cored to assure that the contact was reached. Usually, the Cutler formation was recognized either by the buff, friable sandstone or by a red and brown mudstone or sandstone, in contrast with the gray or greenish-gray color of the Moss Back. Drilling depths ranged from about 65 to 320 feet. Radioactive cores were assayed chemically for U_3O_8 and V_2O_5.

The 2 ore bodies found by drilling were calculated to contain a total of 70,000 tons of ore and to have an average content of 0.575 percent U_3O_8 and 1.17 percent V_2O_5. A tonnage factor of 14 was used in ore calculations.

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METHODS OF DEVELOPMENT AND MINING

Development

The Continental No. 1 mine is developed by a 350-foot slope and a haulage level within the ore stratum. The slope, which has a minimum cross section of 8 by 8 feet, was driven on a 20-percent grade due west and intersects the ore about 320 feet from the surface. For about the first 180 feet from the portal, it is timbered with 8- by 8-inch native-pine sets that are top-lagged. From the bottom of the slope an 8- by 8-foot inclined drift continues due west within the ore stratum. The incline roughly parallels the strike of the sedimentary beds and follows closely the long axis of the east ore body. It was driven on a grade of minus 3.5 percent for 560 feet, steepening to 14 percent for the last 160 feet. It terminates under a timber loading ramp. Along the length driven on the 3.5-percent grade, the inclined drift gradually enters the Cutler formation, so that about 3 feet of the Cutler is exposed. No timber support is required in the inclined drift, but roof bolts are installed in the back on 5- to 10-foot centers to minimize sloughing. A 5- by 7-foot drift continues west for 380 feet from the end of the incline and develops the smaller ore body to the west.

A 22-inch-diameter calyx hole, drilled from the surface, intersects the main haulageway 1,060 feet west of the portal. This small shaft was drilled to serve as an escapeway. A small compressed-air-operated hoist is installed at its collar. In the spring of 1955 the calyx hole was drilled at a contract drilling cost of $15.00 a foot.

Mining

The ore is mined by horizontal open stoping, with random pillar support, (see fig. 3.) The height of the ore and the strength of the overlying rock permit driving rooms wide enough to utilize trackless-type haulage and conveying equipment.

Except in one area, where pillar recovery is in progress, the east ore body is now being opened on the advance. It was the original plan to turn the rooms off the main haulageway at a 45° angle on 50-foot centers. This plan was modified, based on conditions encountered, which has resulted in irregular pillars at random locations. Open stoping with random pillars for support is the mining method most practiced in the uranium mines on the Colorado Plateau.

The smaller west ore body is being explored and developed by drifts of small cross section, which are being advanced to its limits. This deposit contains lower grade ore than the east deposit, and the ore produced to date has been blended with other mine production.

Rooms in the east ore body are driven 8 to 10 feet wide; but where more than 2 rooms intersect, or where they intersect at acute angles, the unsupported span may be as much as 30 feet. They follow the uneven Cutler contact updip to the north and downdip to the south. The rooms are carried to the full height of the ore with a minimum height of 7 feet, which is the clearance needed for the trackless equipment used. Little breaking of waste is necessary to maintain room height. The top of the Cutler can be recognized at most exposures as a buff, friable sandstone directly below the contact. As much as 2 feet of this sandstone has been found to contain 0.06 to 0.10 percent U_3O_8. Occasionally, to gain additional height where the ore thins locally, the bottom of a room is lowered by breaking some of this low-grade Cutler sandstone rather than breaking waste above the ore. Where it is necessary to take down small amounts of waste, the grade of the ore is high enough to stand the resulting dilution.

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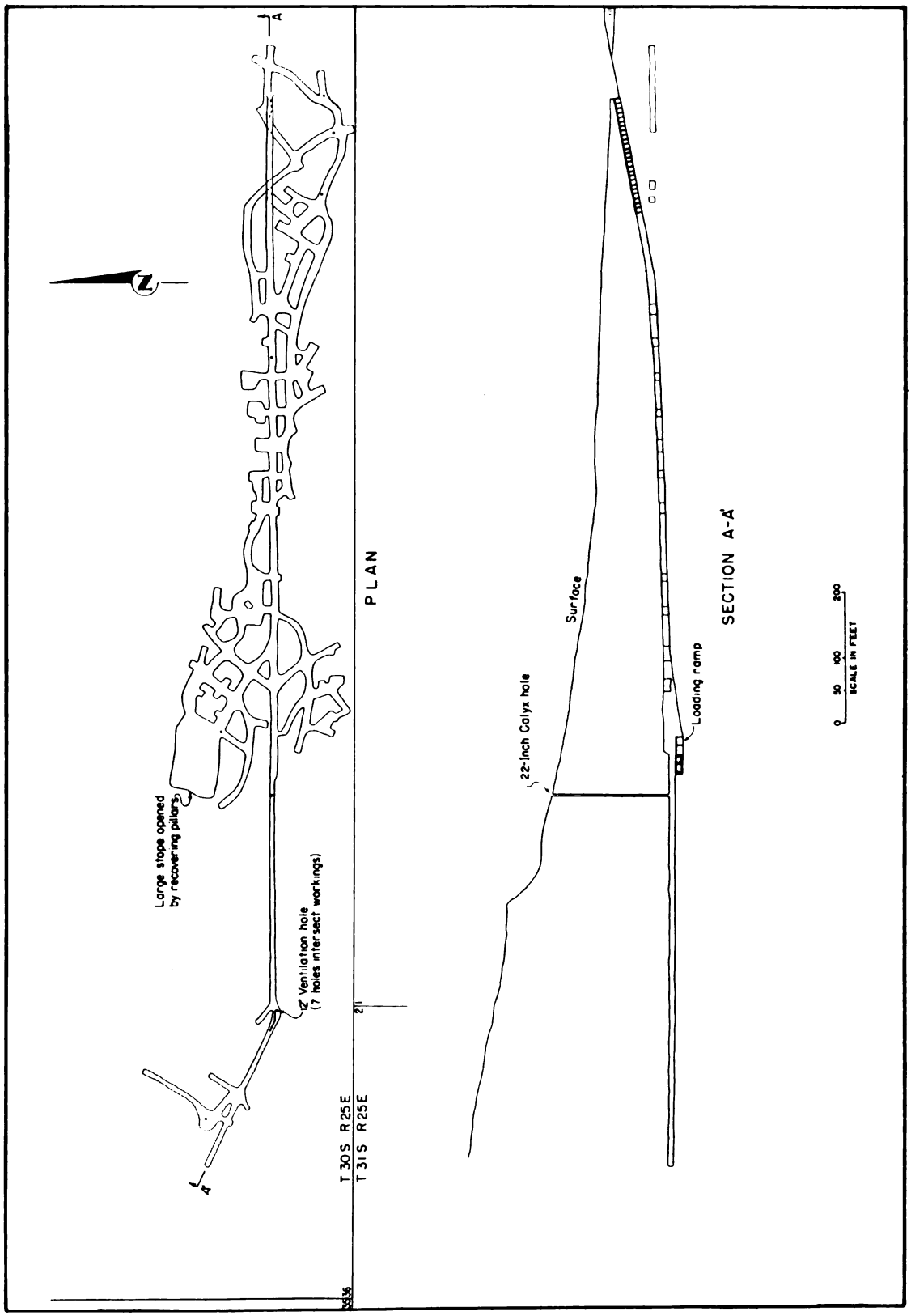

Figure 3. - Plan map and section of underground workings, Continental No. 1 mine.

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The company maintains that the ore must average at least 0.20 percent U_3O_8 to pay for all direct and indirect costs. The foreman strives to maintain a shipping grade of 0.30 to 0.40 percent. Because high- and low-grade ores occur in irregular distribution, blending is necessary. The grade of the ore produced is controlled by switching the points of extraction between various headings. The foreman must keep alert to the charging grade of ore exposures. This can be done by scanning the working faces periodically with a Geiger counter or, more simply, by scanning mine-car grab samples of ore mined from each heading.

Sometimes it is impossible to blend the ore as it is hoisted. When too much low-grade material must be hoisted, it is stockpiled on the surface and later blended gradually with higher grade ore. Several stockpiles of marginal or submarginal rock will be disposed of in this manner. The poorest ore that the company will deliberately mine must contain about 0.12 percent U_3O_8. The lowest grade of rock stockpiled contains 0.03 percent U_3O_8. This material cannot be blended, but it is kept separate for possible future use should more efficient methods of upgrading be developed.

Selective mining will be necessary at the fringes of the ore body, where thinner ore will not stand much dilution. Here scrapers will replace the large haulage units.

Blast-hole drilling is done with Gardner-Denver S-48 rock drills mounted on pneumatic legs. (See fig. 4.) Drill steel is 7/8-inch hexagonal, in 6-foot lengths, with integral 1-5/8-inch tungsten carbide insert-type chisel bits. Rounds are drilled 6 feet deep.

Generally, the ground is easy to drill. Drilling speed is reduced in mudstone because its binding effect on the bit reduces the speed of rotation, and the chisel bit seems to crowd and have less chipping action. The average time required for 1 man to drill a 28-hole round, after the face has been barred down and machine connections have been made, is about 2 hours. The average drilling rate is approximately 80 feet per man-hour.

The standard round in an 8- to 10-foot heading is patterned around a 4-hole burn cut. (See fig. 5.) The burden for the reliever and trim holes ranges from 18 to 24 inches, depending on the ground. To break a round 7 to 8 feet high, 28 to 34 holes are required, with less required in loosely cemented sandstone and more in the harder and better cemented sandstone.

To effect a clean cut the miners group the cut holes in sandstone, if possible, and shoot them one at a time. If the cut is placed in mudstone, the rock within the cut, especially the last foot at the rear of the cut, will often "freeze" rather than be expelled by the blast. The fuses from the cut holes are trimmed to fire individually, with the top and bottom holes going last to break across the bedding planes.

Two types of dynamite are used. An ammonia, 55-percent bulk-strength dynamite with a low density and velocity breaks the loosely-cemented sandstone effectively. A semigelatin, 40-percent bulk-strength, medium-velocity dynamite is used to break the harder ground. Dynamite is purchased in 1- by 8-inch cartridge size. The 1-inch-diameter cartridges are used primarily because of hole squeezing in mudstone. The miners prefer to place the primer cartridges at the bottom of the holes, and the ground generally breaks cleanly to the bottom.

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Figure 4. - Drilling a round with a jackleg-mounted drill, Continental No. 1 mine.

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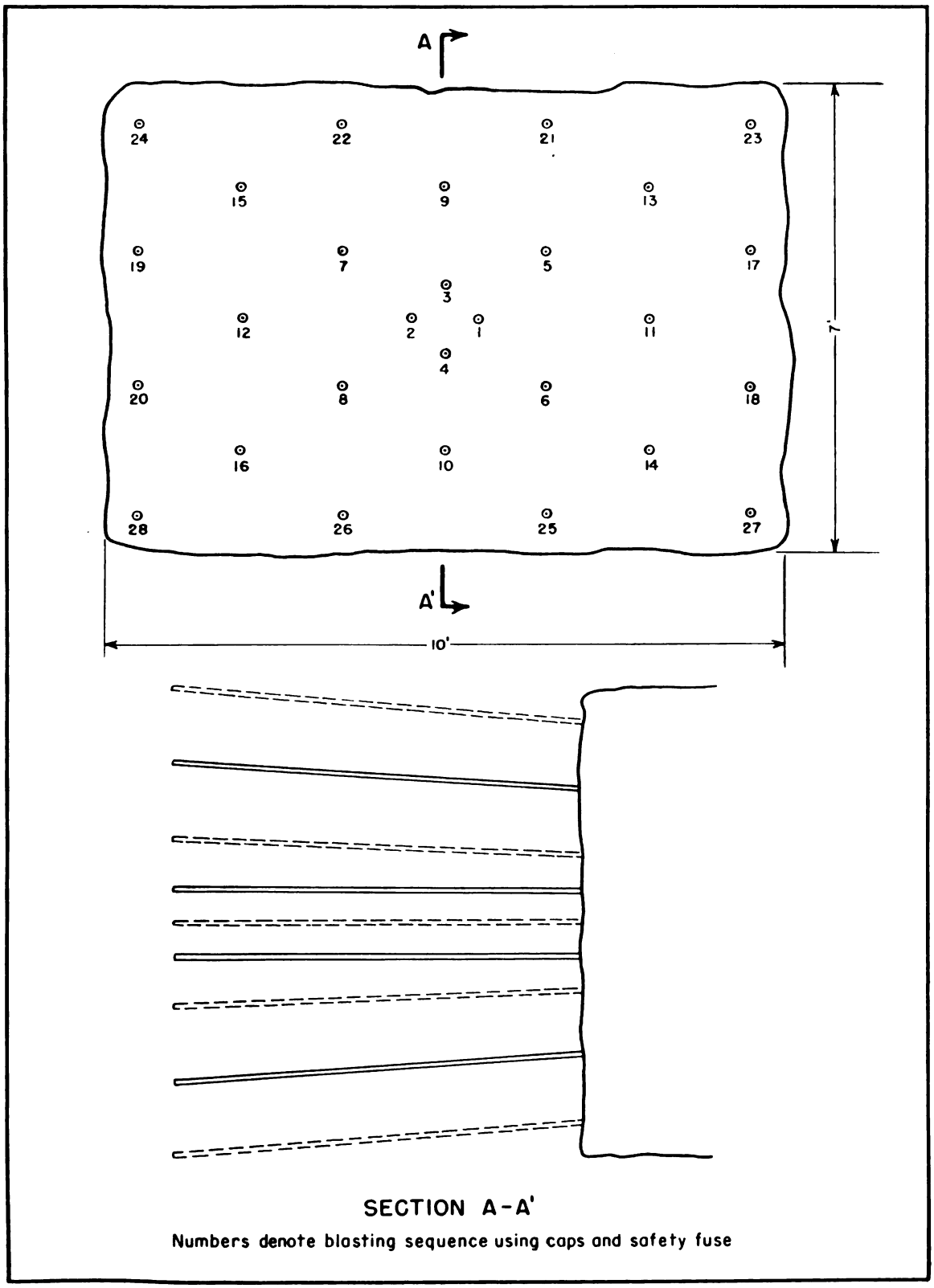

Figure 5. - 28-hole round with 4-hole burn cut, Continental No. 1 mine.

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Roof bolts are used to strengthen sandstone backs and to minimize sloughing where the backs are mudstone. If possible, the miners do not break to the overlying mudstone but leave a cap of sandstone in place. The beam strength of the sandstone is increased by using 6-foot split-rod-and-wedge-type bolts and square or triangular bearing plates. Where mudstone is exposed, sloughing is difficult to control, for it stopes upward as it air slacks. In these areas, punched aircraft landing mats or 2-inch lagging, bolted to the back, increases the effective bearing area of the bolt and minimizes sloughing. (See fig. 6.)

Pillar Recovery

Pillar recovery has begun in one area in the east ore body where the ore limit has been reached. The original rooms were first enlarged to the limits of the ore. As the pillars were reduced, the area took the shape of a single large stope. The open span was supported by timber stulls, 12 to 18 inches in diameter, placed 6 to 12 feet apart, and roof bolts installed on about 4-foot centers. (See fig. 7.) The ore was broken by slab rounds drilled to heave the ore in the direction of the retreat. More stulls were added as the room was enlarged until it reached a size of about 70 by 110 feet. At this time the stulls, which averaged about 1 for every 90 square feet of back, began to take weight. To relieve the weight, the stulls farthest from the working areas were blasted to let the back down, keeping 3 to 5 rows of stulls between the cave and mining faces. Figure 8 shows the breakline of the cave. In this picture the weight is evidenced by the condition of the 8- by 8-inch squeeze block on the timber in the foreground. The timbers in the background have been blasted. Experience has shown that the back may have to be induced to cave to control the breakline. At one part of the cave the mudstone broke in massive blocks approximately 6 feet on a side. It appears that the longer a large span is kept open, the more difficult it is to control the caving. The longer the period, the higher the near-vertical cracks will develop, which produces greater weight and gives less warning before caving. This produces larger cave material, which in turn can roll down and break additional timber, increasing the area of the cave.

Blasting boards, chained to the stulls, keep the ore from scattering when shot. Scrapers are used to convey the ore between the blasting boards and the face. The timber stulls are dapped to receive the 8- by 8-inch squeeze blocks.

Transportation

Four means of transporting the ore underground are used: An Allis-Chalmers HD-6G, diesel-powered, crawler tractor, with a 1-1/3-cubic yard front-end bucket; a Getman model CD, rubber-tired, diesel-powered, Scoot-Crete ore carrier; compressed-air-operated scrapers; and conventional mine cars.

The larger trackless-type haulage units are employed in the east ore body, where the gentle dip and the thickness of the ore permit their use. The minimum operating height for both the front-end loader and the ore carrier is 7 feet. In general, the front-end loader is used for relatively short hauls and for loading the Granby hoisting car from headings that are a short distance from the incline. (See figs. 9 and 10.) The ore carrier is used for long hauls, transporting the ore from faces farther from the incline to the surface. (See fig. 11.) The ore carrier is loaded either by the HD-6G or by the smaller HD-5G. This unit has a capacity of about 3-1/2 tons and has the dump box mounted over its front wheels. It has a Marmon-Herrington 4-wheel drive and has 4-wheel steering.

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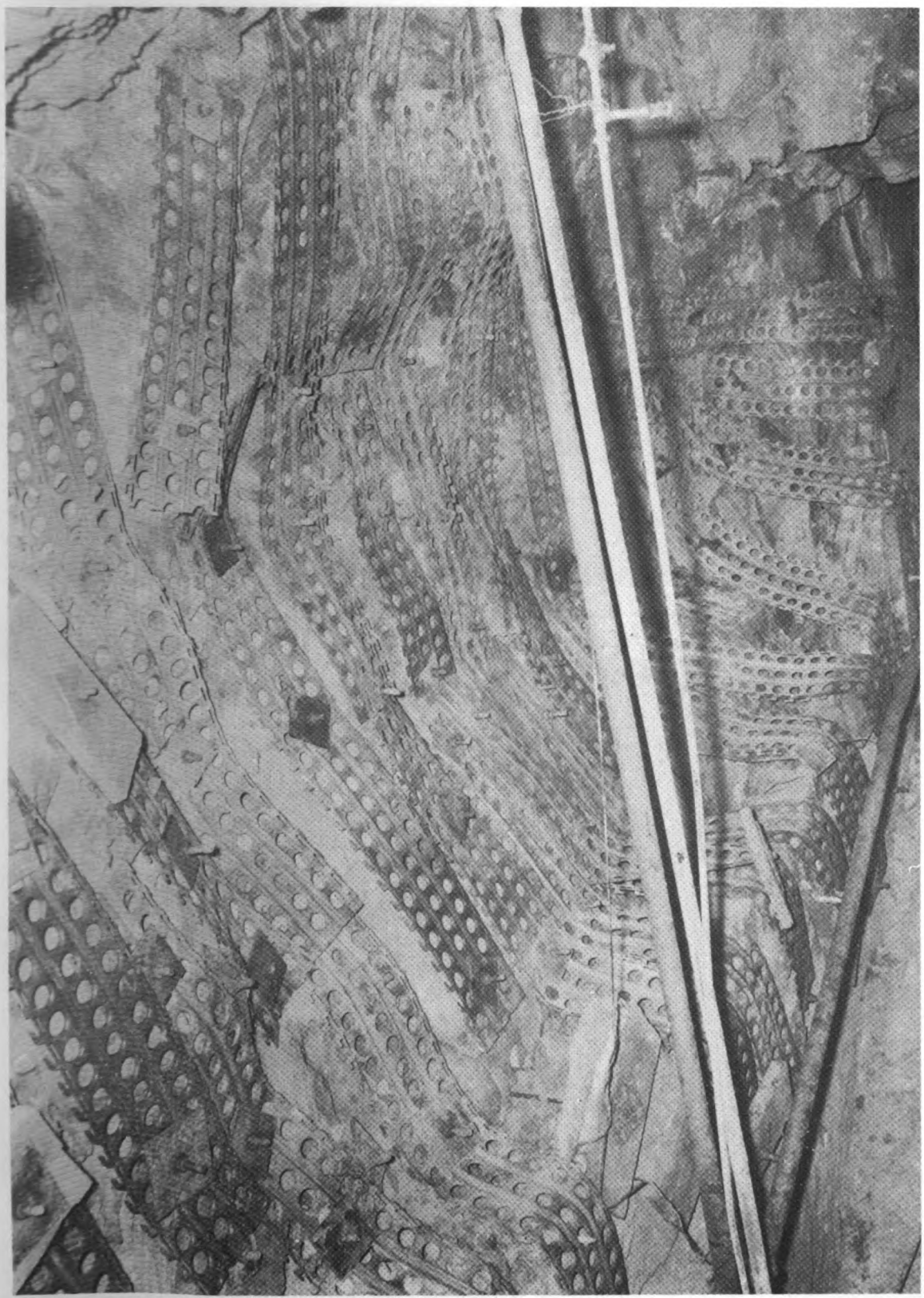

Figure 6. - Mudstone back held with aircraft landing mats, Continental No. 1 mine.

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Figure 7. - Open stope supported by timber stulls, Continental No. 1 mine.

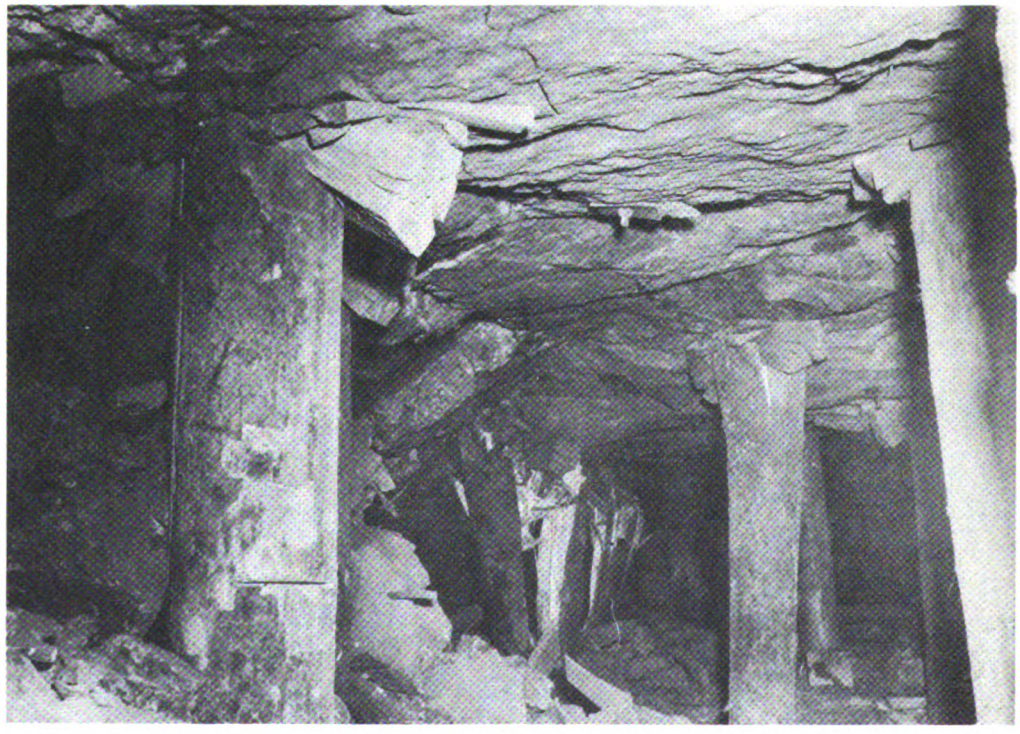

Figure 8. - Breakline at cave where pillars are being recovered, Continental No. 1 mine.

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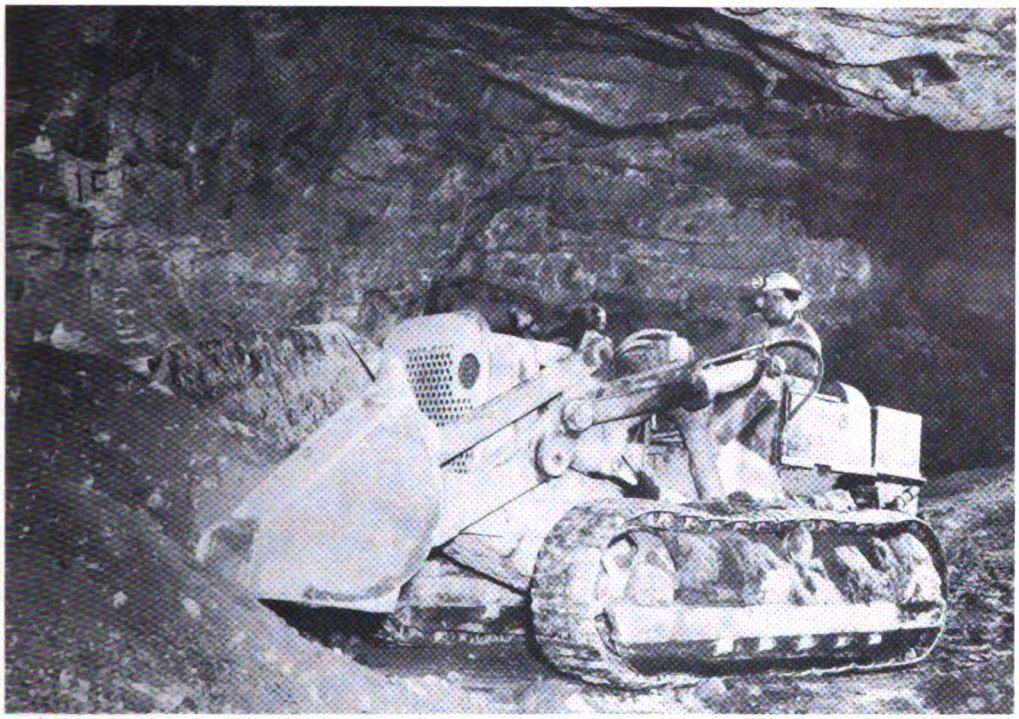

Figure 9. - Loading front-end bucket on Allis-Chalmers Model HD-5G loader, Continental No. 1 mine.

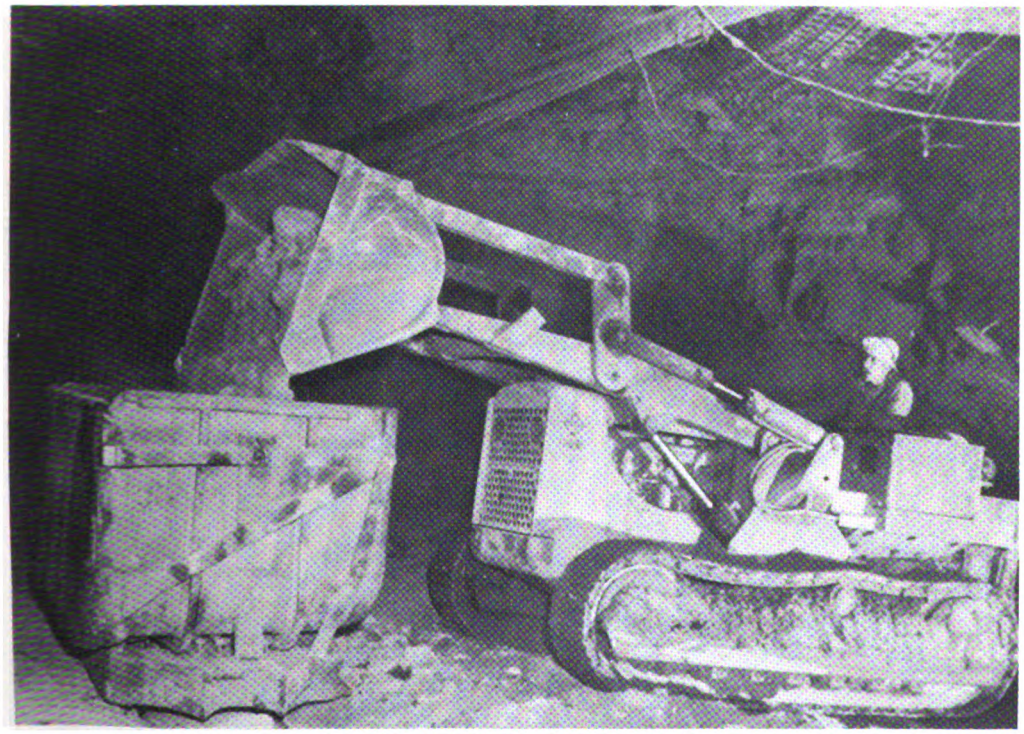

Figure 10. - Loading 91-cubic-foot Granby mine car with Allis-Chalmers HD-6G loader, Continental No. 1 mine.

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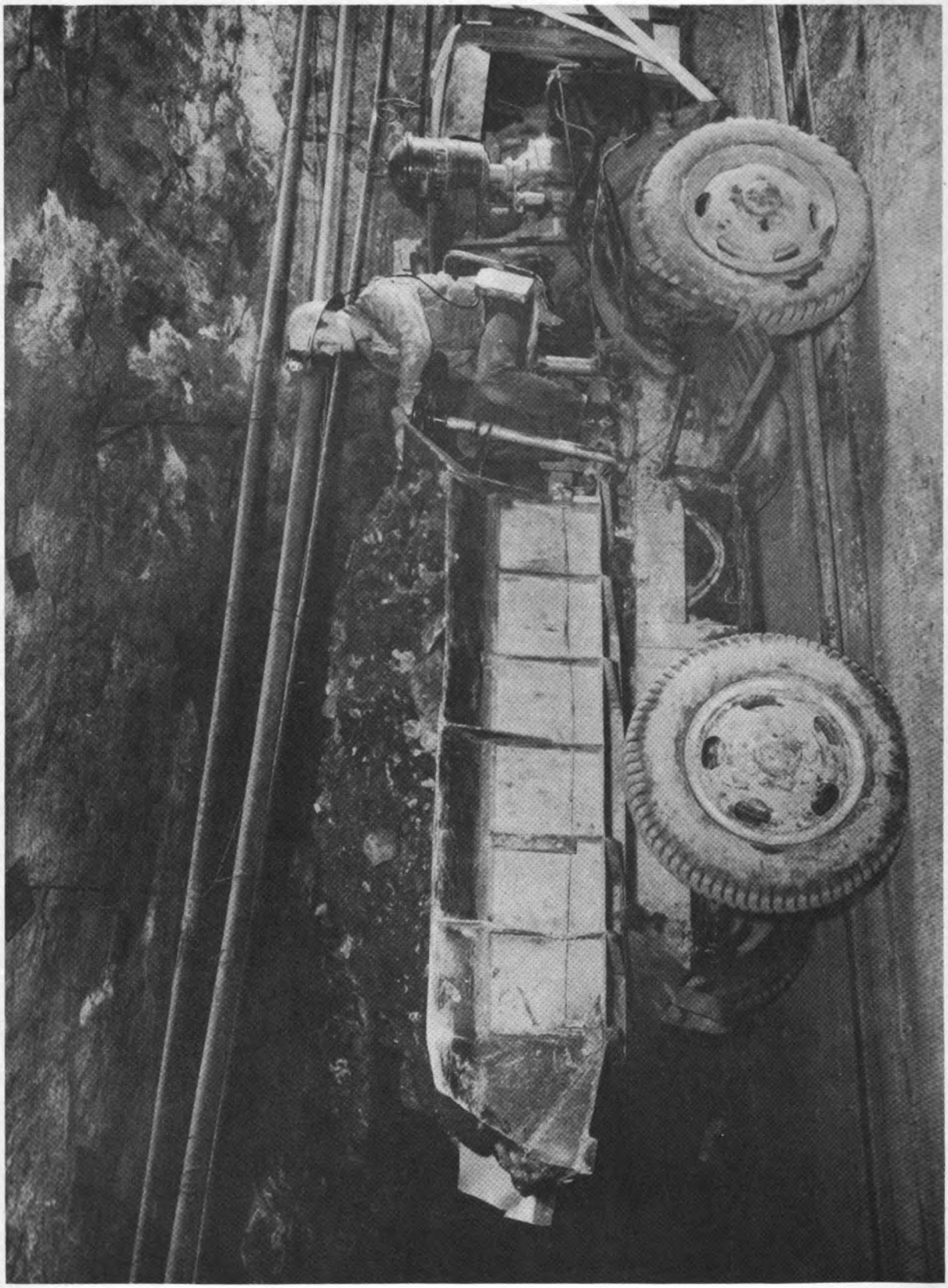

Figure 11. • Scoot-Crete, Model CD, ore carrier, Continental No. 1 mine.

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Compressed-air-operated scrapers are used in the east ore body for pillar recovery. Their size is useful in conveying broken ore through restricted areas. Forty-two-inch scrapers, pulled by 10-hp., 2-drum scraper hoists, are used for this work. A 5-hp. scraper hoist and a 42-inch scraper are used in driving the small development headings in the west ore body.

The ore is transported to the surface by the ore carrier or is hoisted in a 91-cubic-foot-capacity Granby mine car. The track in the incline and slope has 30-pound rails laid to 24-inch gage. Rope idlers are spaced 35 to 50 feet apart.

The hoist is a single-drum, Skagit model GU-10. The drum barrel has a diameter of 11 inches and a length of 22 inches, with a capacity of 1,340 feet of 5/8-inch cable. The hoist is powered by a Ford V-8, 100-hp., industrial engine. Electric hoisting-signal switches are placed at the loading points in the incline. When both the ore carrier and the Granby car are moving ore to the surface, their movement in the haulageway is directed by a system of signals.

All diesel equipment used underground is equipped with water-type exhaust coolers.

SURFACE PLANT

The surface plant is small but adequate for the needs of the operation. There are four small buildings at the mine. The compressor house (24 by 24 feet) and the shop and dry-room building (12 by 32 feet) are Butler-steel structures built of lightweight steel frames covered with corrugated-steel sheeting. The hoisthouse (16 by 24 feet) has a timber frame with corrugated-steel sheeting, and the warehouse (10 by 10 feet) is an all-wood structure.

Compressed air is supplied by a Gardner-Denver, WHK, 500-c.f.m., 2-stage compressor, with a Caterpillar D-13000 diesel drive; and a Gardner-Denver WBG 365 c.f.m. 2-stage compressor, with a Caterpillar D8800 diesel drive. The limited electric-power needs at the mine and camp are met by a small, 25-kw., 240-volt Electric Machinery Manufacturing Co. generator unit. The 6-cylinder internal-combustion engine has been adapted to operate on propane gas, which is piped from a 1,000-gallon storage tank.

The hoisthouse was constructed on a timber trestle, which is 15 feet above the mine yard. The trestle abuts the rock-fill surface incline, which is approximately on the same grade as the slope. From the top of the trestle the Granby hoisting car is tipped by a camel-back dump trip to empty its load onto a horizontal grizzly. The grizzly is made of 30-pound rail and extends over the open-surface storage bin. The bin is separated from the trestle by a timber wall lined with 12-gage steel plate. The capacity of this type storage is equal to approximately 2 days' production. Waste is dumped along side of the ore pile and moved to the waste dump by the Allis Chalmers, HD-5G, front-end loader.

The ore is hauled 86 miles to the buying station at Thompson, Utah, and sold to the Union Carbide Nuclear Co. Steady improvement of haulage roads, with black-topping to within 10 miles of the mine, has resulted in a steady decrease in haulage costs from $0.075 to $0.05 a ton-mile.

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EQUIPMENT AND EXPLOSIVES

Mining equipment at the Continental No. 1 mine consists of the following:

Number	Equipment
1	Tractor, crawler, front-end loader, Allis-Chalmers, HD-6G.
1	Tractor, crawler, front-end loader, Allis-Chalmers, HD-5G.
1	Ore Carrier, Scoot-Crete, model CD.
1	Compressor, 500 c.f.m., Gardner-Denver, model WHK.
1	Compressor, 365 c.f.m., Gardner-Denver, model WBG.
1	Generator plant, 25 kw.
1	Hoist, single-drum, Skagit, model GU-10.
1	Mine car, Granby-type, 91-cubic feet, C. S. Card.
1	Mine car, end-dump-type, 20-cubic feet, C. S. Card.
8	Rock drills, Gardner-Denver, S-48, pneumatic-leg mounted.
2	Stoper, Gardner-Denver model R-94.
1	Impact wrench, Thor, model 6973.
2	Scraper hoist, 10 hp., compressed-air, 2-drum, Gardner-Denver.
1	Scraper hoist, 7.5 hp., compressed-air, 2-drum, Gardner-Denver.
1	Scraper hoist, 5 hp., compressed-air, 2-drum, Gardner-Denver.
2	Tugger hoist, 5 hp., compressed-air, 1-drum, Gardner-Denver.
1	Fan, 4,700 c.f.m., axial-flow type, elec. drive.
2	Fan, centrifugal, Buffalo No. 7, with gas and elec. drives.
1	Locomotive, company-made, 7-1/2 hp., diesel engine.

Dynamite consumption during the period of March 1 to September 31, 1956, averaged 2.9 pounds per ton of ore. Explosives cost $0.66 per ton of ore.

PRODUCTION RATES

Production from the Continental No. 1 mine has averaged about 1,500 tons of ore a month. The unit costs, tabulated at the end of this report, were incurred during a period when production averaged 1,655 tons a month. All work during this period was in ore headings, and therefore no costs are charged to development. The man-hours expended underground equaled 1.16 for each ton of ore, and the tons per man-shift equaled 6.9. The tons per man-shift for all labor, including that on the surface and supervision, was 5.6.

VENTILATION

Mine air is exhausted at the surface through seven 12-inch, vertical, churn-drill holes that connect with the mine workings. Three small exhaust fans (2 centrifugal and 1 axial-flow type) are installed at the collars of any 3 of these holes nearest the faces where mining is in progress. Mine air is sampled monthly to determine the concentration of radon daughter elements.

LABOR CLASSIFICATIONS, WAGES, AND INCENTIVE-BONUS SYSTEM

Twelve men are employed at the Continental No. 1 mine - 7 on the day shift and 5 on the night shift. Five men on each crew work alternate shifts, changing every 2 weeks. Two men, a mechanic and his helper, work only on day shifts. A crew consists of 1 hoistman, 1 loader and transport man, 2 miners, and 1 working-shift boss. The entire mine force, except supervisory personnel, is paid $2.05 an hour. The wage differential for work on the night shift is $0.06 an hour. The work schedule

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is 12 days on and 2 off, with the off days falling on the weekends. The shift hours are 7:00 a.m. to 3:30 p.m. and 6:00 p.m. to 2:30 a.m.

The miners share equally in a family-type incentive-bonus system. This system is based on pounds of U_3O_8 produced per man-shift. It not only provides the incentive to increase the tonnage; but, by laying stress on pounds of U_3O_8, the miners appreciate the value of producing clean ore.

The premise of the system is that mine production should average 20 pounds of U_3O_8 per man-shift for all on the days-pay force. The bonus award is increased progressively for each 7.5-pound increment over the base of 20. The bonus scale is as follows:

U_3O_8 produced per man-shift, pounds	Bonus per pound per man-shift
0 to 20.0	No bonus
20.0 to 27.5	$0.25
27.5 to 35.0	.50
35.0 to 42.5	.75
Above 42.5	1.00

Bonus payments are made monthly and separately from regular wage payments. The bonus per man-shift is arrived at by dividing the number of pounds of U_3O_8 produced by the total man-shifts worked, then multiplying the pounds in each interval over 20 by its respective bonus. To clarify the above, the following example is cited.

During 1 month, 1,650 tons of uranium ore, which contained 11,622 pounds of U_3O_8, was produced by 12 men who worked an average of 26 shifts each. The pounds produced per man-shift is then 37.25. This figure is 17.25 pounds over the base of 20, and the bonus per man-shift is $7.313, which is calculated as follows:

Pounds		
7.50	(27.5 - 20.0) x $0.25 =	$1.875 bonus
7.50	(35.0 - 27.5) x .50 =	3.750 bonus
2.25	(37.25 -35.0) x .75 =	1.688 bonus
Total 17.25		$7.313 bonus per shift

Each man, then is paid a bonus of $0.914 for each straight-time hour and $1.371 for each overtime hour worked during the month.

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SUMMARY OF COSTS

Name of mine: Continental No. 1 — Mining method: Open stoping with random pillar support

Ore hoisted, tons: 9,930 — Period covered: Mar. 1 - Sept. 30, 1956

1. Direct costs per ton of ore hoisted:

	Labor	Supervision[1]	Compressed air[2]	Drill steel and bits	Explosives	Diesel fuel, oil, and grease	Other supplies	Total
Mining:								
Drilling	$1.09	$0.16	$0.15	$0.42				$1.82
Blasting	.16	.02			$0.66			.84
Mucking	.84	.12				$0.09		1.05
Timbering and roof bolting	.54	.07					$0.50	1.11
Transportation:								
Tramming	.46	.06	.03			.10		.65
Hoisting	.65	.09					.06	.80
General underground expense:								
Air and water lines	.08						.11	.19
Track	.25						.02	.27
Ventilation	.14						.35	.49
Surface expense:								
Handling and sorting ore	.08							.08
Equipment maintenance	.44						.52	.96
Total	$4.73	$0.52	$0.18	$0.42	$0.66	$0.19	$1.56	$8.26

2. Indirect cost per ton of ore hoisted:[3]

Engineering, surveying, and assaying	$0.19
Camp expense	.37
Automotive expense	.11
Travel, supervision	.05
Miscellaneous, mine	.06
	$0.78

3. Summary of costs in units of labor, power, and supplies:

	Mining	Total
A. Labor (man-hours per ton)		
Breaking (drilling and blasting)	0.34	
Timbering and roof bolting	.15	
Mucking	.23	
Tramming and hoisting	.31	
General, underground	.13	
Total, underground labor[4]	1.16	
Surface labor	.16	
Supervision	.12	
Total, all labor and supervision		1.44
Labor (tons per man-shift)		
Underground labor	6.9	
Surface and supervision	28.9	
Average of all labor and supervision		5.6
Labor and supervision, percent of total cost		63.56
B. Supplies: Explosives (40- and 55-percent bulk-strength dynamite), pounds per ton		2.9
Supplies, percent of total cost		36.44

1/ Supervision does not include working shifters. Shifters' wages included under labor costs.
2/ Compressed-air cost of $0.18 equals $0.06 for maintenance and operating labor, and $0.12 for fuel and repair parts.
3/ Does not include amortization, depreciation, taxes, royalty, insurance, etc.
4/ Includes the man-hours of the working shifters.

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